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PTO/SB/05 (12/97)
Approved for use through 09/30/00. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

JC930 U.S. PTO 09/28/00

jc836 U.S. PTO 09/677701 09/28/00

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b)

Attorney Docket No. 042390.P9481 Total Pages 2

First Named Inventor or Application Identifier Terrance Dishongh

Express Mail Label No. EL627464508US

ADDRESS TO: **Assistant Commissioner for Patents**
Box Patent Application
Washington, D. C. 20231

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents.

1. X Fee Transmittal Form
(Submit an original, and a duplicate for fee processing)

2. X Specification (Total Pages 14)
(preferred arrangement set forth below)
- Descriptive Title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claims
- Abstract of the Disclosure

3. X Drawings(s) (35 USC 113) (Total Sheets 2)

4. X Oath or Declaration (Total Pages 6)(Unsigned)
   a. ___ Newly Executed (Original or Copy)
   b. ___ Copy from a Prior Application (37 CFR 1.63(d))
   (for Continuation/Divisional with Box 17 completed) **(Note Box 5 below)**
   i. ___ DELETIONS OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).

5. _ Incorporation By Reference (useable if Box 4b is checked)
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. _ Microfiche Computer Program (Appendix)

7. __ Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
a. ____ Computer Readable Copy
b. ____ Paper Copy (identical to computer copy)
c. ____ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. __ Assignment Papers (cover sheet & documents(s))
9. __ a. 37 CFR 3.73(b) Statement (where there is an assignee)
   __ b. Power of Attorney
10. __ English Translation Document (if applicable)
11. __ a. Information Disclosure Statement (IDS)/PTO-1449
    __ b. Copies of IDS Citations
12. __ Preliminary Amendment
13. X Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
14. __ a. Small Entity Statement(s)
    b. Statement filed in prior application, Status still proper and desired
15. __ Certified Copy of Priority Document(s) (if foreign priority is claimed)
16. X Other: Express Certificate of Mailing

17. **If a CONTINUING APPLICATION,** check appropriate box and supply the requisite information:

____ Continuation ____ Divisional ____ Continuation-in-part (CIP)

of prior application No: _

18. **Correspondence Address**

_____ Customer Number or Bar Code Label ____________________
(Insert Customer No. or Attach Bar Code Label here)

or

X Correspondence Address Below

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FEE TRANSMITTAL FOR FY 2000

TOTAL AMOUNT OF PAYMENT ($) 690.00

Complete if Known:
Application No. New Application
Filing Date Herewith
First Named Inventor Terrance Dishongh
Group Art Unit Not yet assigned
Examiner Name Not yet assigned
Attorney Docket No. 042390.P9481

METHOD OF PAYMENT (check one)

1. [ ] **The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:**

Deposit Account Number 02-2666
Deposit Account Name ____

[X] **Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17**

2. X **Payment Enclosed:**
X **Check**
____ **Money Order**
____ **Other**

FEE CALCULATION

1. **BASIC FILING FEE**

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	690	201	345	Utility application filing fee	690.00
106	310	206	155	Design application filing fee	
107	480	207	240	Plant filing fee	
108	690	208	345	Reissue filing fee	
114	150	214	75	Provisional application filing fee	

SUBTOTAL (1) $ 690.00

2. **EXTRA CLAIM FEES**

			Extra Claims		Fee from below		Fee Paid
Total Claims	17	– 20** =	0	X		=	0.00
Independent Claims	3	– 3** =	0	X		=	0.00
Multiple Dependent						=	

****Or number previously paid, if greater; For Reissues, see below.**

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	78	202	39	Independent claims in excess of 3
104	260	204	130	Multiple dependent claim, if not paid
109	78	209	39	**Reissue independent claims over original patent
110	18	210	9	**Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) $ 0.00

Patent fees are subject to annual revisions. Small Entity payments must be supported by a small entity statement, otherwise large entity fees must be paid.
See Forms PTO/SB/09-12

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for response within first month	
116	380	216	190	Extension for response within second month	
117	870	217	435	Extension for response within third month	
118	1,360	218	680	Extension for response within fourth month	
128	1,850	228	925	Extension for response within fifth month	
119	300	219	150	Notice of Appeal	
120	300	220	150	Filing a brief in support of an appeal	
121	260	221	130	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive unavoidably abandoned application	
141	1,210	241	605	Petition to revive unintentionally abandoned application	
142	1,210	242	605	Utility issue fee (or reissue)	
143	430	243	215	Design issue fee	
144	580	244	290	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	690	246	345	For filing a submission after final rejection (see 37 CFR 1.129(a))	
149	690	249	345	For each additional invention to be examined (see 37 CFR 1.129(a))	

Other fee (specify) ______________________ ________

Other fee (specify) ______________________ ________

SUBTOTAL (3) $ 0.00

*Reduced by Basic Filing Fee Paid

SUBMITTED BY:

Typed or Printed Name: Michael A. Bernadicou

Signature M. Bernadicou Date 9/28/00

Reg. Number 35,934 Deposit Account User ID 02-2666
(complete if applicable)

APPLICATION FOR UNITED STATES LETTERS PATENT

METALLURGICALLY ENHANCED HEAT SINK

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Docket No. 042390.P9481

EXPRESS MAIL CERTIFICATE OF MAILING

"Express Mail" mailing label number: EL627464508US

Date of Deposit: September 28, 2000

I hereby certify that I am causing this paper or fee to be deposited with the United States Postal Service "Express Mail Post Office to Addressee" service on the date indicated above and that this paper or fee has been addressed to the Assistant Commissioner for Patents, Washington, D. C. 20231

Julie Arango
(Typed or printed name of person mailing paper or fee)

Julie Arango
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September 28, 2000
(Date signed)

METALLURGICALLY ENHANCED HEAT SINK

FIELD OF THE INVENTION

The present invention relates generally to the field of electronic microcircuit fabrication and, more particularly, to a process of fabricating a metallurgically enhanced heat sink.

BACKGROUND

A typical microelectronic package includes an integrated circuit device (e.g., a silicon chip) mounted to a carrier substrate with an epoxy-based material disposed between the die and the substrate. A heat sink (e.g., aluminum or copper) is generally included in the package and has direct contact with the die so that heat generated by the die can dissipate by convection directly into the surrounding air.

However, as the industry moves towards faster and smaller microelectronic devices, effective heat management is becoming more difficult. For example, the miniaturization of microelectronic devices involves not only crowding an increasing number of circuits on to a single chip, but also reducing the overall chip package size. Although smaller devices are necessary for certain high-performance applications (e.g., hand-held computers, portable telecommunications equipment, and the like) these devices tend to generate more heat due to a higher integration of circuits. One problem associated with ineffective thermal management can cause the central portion of a die, secured to a substrate, to curve or bend. This may cause some of the electrical connections between the die and the substrate to separate. Another damaging effect caused by thermally induced curving includes cracking and/or breaking of the die. In this

instance, tensile stresses occur in the outer layer of the die as it bends. If these stresses are greater than the fracture strength of the die, it chips or breaks. Moreover, as the temperature becomes very hot, the inner dielectric layer may melt and cut off the electrical connection leading to total failure of the device.

One method of solving this problem has been to make heat sinks more efficient. For example, by reducing the thermal resistance between the heat sink and the die (i.e., by using a heat conductive adhesive such as grease, phase changing material, or solder alloy to attach the die to the heat sink) the heat transfer process is improved. Another technique has been to fabricate heat sinks from materials such as kovar or other expensive alloys with higher thermal conductivity than more conventional materials such as aluminum and copper. Nevertheless, alloys such as kovar do not provide a cost effective packaging solution.

As the advances in microelectronic fabrication continue to yield even more densely packaged high power transistors that are operated at faster and faster clock speeds, the problems associated with heat generation and heat dissipation will only become more acute. Therefore, it would be advantageous to enhance the thermal conductivity of heat sinks.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example, and not limitation, in the figures of the accompanying drawings in which like reference numerals refer to similar elements and which:

Figure 1 is a schematic illustration of a conventional microelectronic package according to an embodiment of the present invention.

Figure 2 is a schematic illustration of the grain structure of an aluminum alloy used in a conventional heat sink before a metallurgical process has been implemented according to an embodiment of the present invention.

Figure 3 is a schematic illustration of the grain structure of an aluminum alloy used in a heat sink after a metallurgical process has been implemented according to an embodiment of the present invention.

DETAILED DESCRIPTION

Throughout the following description specific details are set forth in order to provide a more thorough understanding of the invention. However, the invention may be practiced without these particulars. In other instances, well known elements have not been shown or described in detail to avoid unnecessarily obscuring the present invention. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense.

The present invention provides for a process of constructing a heat sink fabricated from conventional material (e.g., aluminum) that is metallurgically treated to enhance its thermal conductivity. A heat sink is subjected to the appropriate thermal treatment to obtain a coarse grain structure. A conventional heat sink will display improved thermal conductivity with a coarse grain structure than with a fine one.

As is well known in the art of thermal dynamics, conduction is accomplished by the short range interaction of electrons and/or molecules. Heat may be conducted when the motions of energetic (hotter) molecules are passed on to nearby, less energetic (cooler) molecules. However, a more effective method of heat conduction is the migration of energetic free electrons. Aluminum, with a high free electron density, is a good thermal and electrical conductor. However, one obstruction to the movement of atomic and/or molecular species is the presence of grain boundaries, which hinders the movement of these species from one grain to another. If the number of grain boundaries that obstruct the movement of the atomic and/or molecular species were reduced (i.e., if a coarse grain structure were obtained), there would be a considerable improvement in the conductive properties of the material.

Although grain coarsening reduces the strength of the material, heat sinks are not dominant load bearing structures. Thus, a certain degree of grain coarsening may be achieved that strikes a balance between the desired strength of the heat sink and the enhanced thermal conductivity of the heat sink material.

Referring now to Figure 1, there is shown a schematic illustration of a conventional microelectronic package 100 in accordance with an embodiment of the present invention. A microelectronic die 110 (e.g., silicon or galium arsenite) is mounted to a package substrate 120 (e.g., organic or ceramic) using flip chip or C4 attachment ("Controlled Collapse Chip Connection") where an array of minute solder balls 115 on an active surface of the die 110 are aligned with an array of bond pads (not shown in this view) on an active surface of the package substrate 120. In other instances, the die 110 may be mounted to the substrate 120 using Chip-on-Flex ("COF") packaging (not shown in this view) where a flex component (i.e., the package substrate) is attached with an adhesive layer to an active surface of the die 110. Of course, various other types of electrical connections between the die 110 and the substrate 120 may also be used.

In the embodiment illustrated by Figure 1, the substrate 120 may be fabricated of conventional laminates such as FR-4, fiberglass or bismaleimide-triazine (BT) material, of coated aluminum, or of alumina, ceramic, or other suitable material and includes multiple dielectric layers and multiple conductive layers (not shown in this view). Conductors on the substrate 120 may be formed of metals such as copper, aluminum, gold or silver, or by conductive inks formed by known technologies such as by thin-film or thick-film deposition.

A conventionally shaped heat sink 130 is thermally coupled to the backside of the die 110 using a heat conductive adhesive 125 (e.g., grease, phase changing material, solder, and the like). An advantage of using grease or phase changing material as the heat conductive adhesive 125 is that the integrity of the thermal interface bondline thickness between the die 110 and the heat sink 130 is always maintained. Of course, various other types of heat conductive adhesives may be used as well. In this example, the heat sink 130 is formed of aluminum. It will be appreciated by those skilled in the art that the present embodiment is readily applicable to heat sinks 130 of other component compositions, for example copper, titanium, and the like. In addition, although the heat sink 130 in the embodiment illustrated by Figure 1 is comprised of a horizontal plane, the shape and size of the heat sink 130 is flexible.

Referring now to Figure 2 there is shown a schematic illustration of the grain structure of an aluminum alloy before a metallurgical process has been implemented 200 according to an embodiment of the present invention. A fine grain structure 210, 220, 230, etc., throughout the thickness of the material obstructs the movement of atomic and/or molecular species 240 by the presence of numerous grain boundaries 250, 260, 270, etc. Although the aluminum alloy has a high free electron density (not shown in this view) and is thus a good thermal and electrical conductor, it would be helpful to reduce the number of grain boundaries 250, 260, 270, etc., in the material to enhance the movement of the atomic and/or molecular species 240.

Referring now to Figure 3 there is shown the grain structure of an aluminum alloy used in a heat sink that has undergone a metallurgical process 300 according to an embodiment of the present invention. The process of fabricating the heat sink includes

changing the microstructure of the alloy to increase the size of the grain structure 310, 320, 330, etc. As is well known in the metallurgical arts, grain growth and coarsening in the aluminum alloy T6061 (a popular material for commercially available heat sinks) can be achieved by simply heating the aluminum in excess of 850.degree.F. to 900.degree.F which will lead to a secondary re-crystallization grain growth. Of course, the process of the invention is not limited to the aluminum alloy T6061 and may be applicable to all aluminum alloys (or to any other alloys or metals used in the fabrication of heat sinks) which have precipitating constituents. Of course, care must be taken to develop a particular metallurgical process suitable for each alloy family.

In the next step of the process, the heat sink is subjected to a relatively slow reduction in temperature from room temperature (generally about 72.degree.F.) to an intermediate temperature (such as -100.degree.F.). For example, the material may be gradually cooled to the intermediate temperature by being suspended directly over an open container containing a bath of cryogenic material such as liquid nitrogen until an intermediate temperature is maintained throughout. The generally accepted standard well known in the metallurgical arts is to provide for a minimum of approximately one hour per inch cross section of the material to reach an intermediate temperature. The heat sink is then placed directly in the bath of liquid nitrogen, thereby attaining a quick reduction in the temperature of the heat sink to a cryogenic temperature (i.e., to about -327.degree.F. which is the temperature of the liquid nitrogen). Again, the accepted standard is to provide for a minimum of one hour per inch of cross section of the heat sink to reach the cryogenic temperature. Of course, other methods may be used, so long as the heat sink reaches the appropriate cryogenic temperature.

In the conventional cryogenic quenching process, the material is then gradually brought back up to room temperature to enhance various qualities of the material (such as hardness, stability, etc.). In the present embodiment, the cryogenic quenching process involves bringing the temperature of the heat sink immediately up to room temperature after the cryogenic treatment. The coarse grain structure 310, 320, 330, etc., of the heat sink that is attained by the cryogenic quenching process is thus retained, reducing the number of grain boundaries 340, 350, 360, etc., that obstruct the movement of the atomic and/or molecular species 370. As described herein, a reduction in grain boundaries 340, 350, 360, etc., leads to a considerable improvement in the thermal conductive properties of the aluminum.

Although the initial heat treatment (i.e., raising the aluminum in excess of 850.degree.F. to 900.degree.F.) weakens the aluminum by reducing the tensile and yield strength and may result in a roughening of the surface upon cooling back to room temperature, the cryogenic quenching process stress relieves the condition and helps strengthen the aluminum. Again, since the heat sink is not a dominantly load bearing structure, the reduction in material strength can be very well tolerated.

Although the description herein describes a cryogenic quenching process that involves immersing the material into a bath of liquid nitrogen, it should be understood that any type of cryogenic quenching process well known in the metallurgical arts may be used. For instance, the material may be treated in a cryogenic chamber or any other type of freezing apparatus.

In addition, many different tempering parameters may be utilized depending on the type of material used for the heat sinks, the size of the heat sink, and their configuration.

Thus, a process for metallurgically enhancing a heat sink has been described. Although the foregoing description and accompanying figures discuss and illustrate specific embodiments, it should be appreciated that the present invention is to be measured only in terms of the claims that follow.

CLAIMS

1. A process for fabricating a heat sink, comprising:

providing a heat sink; and

treating the heat sink to a cryogenic quenching process.

2. The process of Claim 1 wherein the heat sink is fabricated from a metal alloy having precipitating constituents.

3. The process of Claim 1 wherein the heat sink is part of a microelectronic package including a die affixed to a carrier substrate.

4. The process of Claim 1 further comprising prior to treating the heat sink to the cryogenic quenching process first treating the heat sink to a temperature high enough to lead to a secondary re-crystallization grain growth, which changes the microstructure of the heat sink from a fine grain to a coarse grain.

5. The process of Claim 1 wherein the treating of the heat sink to the cryogenic quenching process includes gradually lowering the heat sink to a cryogenic temperature and then immediately raising the temperature of the heat sink.

6. The process of Claim 4 wherein the changing of the microstructure of the heat sink from a fine grain to a coarse grain improves the thermal conductivity of the heat sink

by reducing the number of grain boundaries in the heat sink that obstruct the movement of atomic and molecular species.

7. The process of Claim 1 further comprising affixing the heat sink to a microelectronic die mounted to a package substrate.

8. A process of fabricating a heat sink, comprising:

providing a heat sink comprised of a metal alloy;

raising the temperature of the heat sink to cause a secondary re-crystallization grain growth in the metal alloy; and

treating the heat sink to a cryogenic quenching process.

9. The process of Claim 8 wherein the metal alloy has precipitating constituents.

10. The process of Claim 8 wherein the thermal conductivity of the heat sink is improved by changing the microstructure of the metal alloy from a fine grain structure to a coarse grain structure.

11. The process of Claim 8 wherein the heat sink is fabricated from an aluminum alloy.

12. The process of Claim 8 wherein the heat sink is fabricated from a copper alloy.

13. The process of Claim 8 further comprising affixing the heat sink to a microelectronic die mounted to a package substrate.

14. A process of fabricating a heat sink, comprising:

providing a heat sink; and

expanding the grain structure in the heat sink from a fine grain to a coarse grain to enhance the thermal conductivity of the heat sink.

15. The process of Claim 14 wherein the heat sink is fabricated from a metal alloy with secondary re-crystallization grain growth.

16. The process of Claim 15 further comprising treating the heat sink to a cryogenic quenching process by gradually lowering the heat sink to a cryogenic temperature and then immediately raising the temperature.

17. The process of Claim 14 wherein the heat sink is part of a microelectronic package which includes a die affixed to a package substrate, the thermal conductivity of the heat sink improved by reducing the grain boundaries that obstruct the movement of atomic and molecular species.

ABSTRACT

A metallurgical process expands the grain structure in a heat sink from a fine grain to a coarse grain to improve the thermal conductivity of the heat sink. The temperature of the heat sink is raised to a level high enough to lead to a secondary re-crystallization grain growth in the metal alloy. The temperature of the heat sink is then gradually lowered to a cryogenic temperature and then immediately brought back up to ambient temperature to strengthen the material.

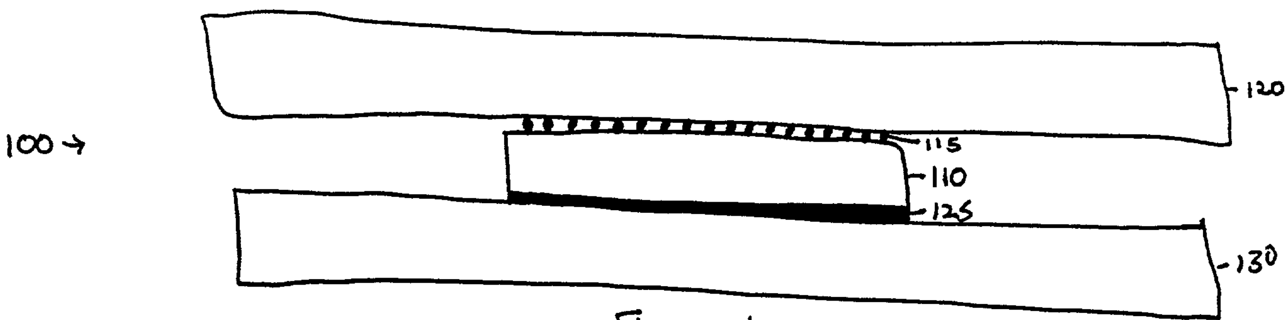

Figure 1

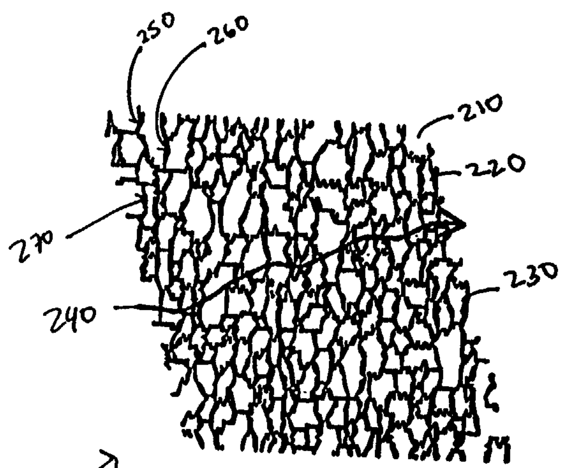

Figure 2

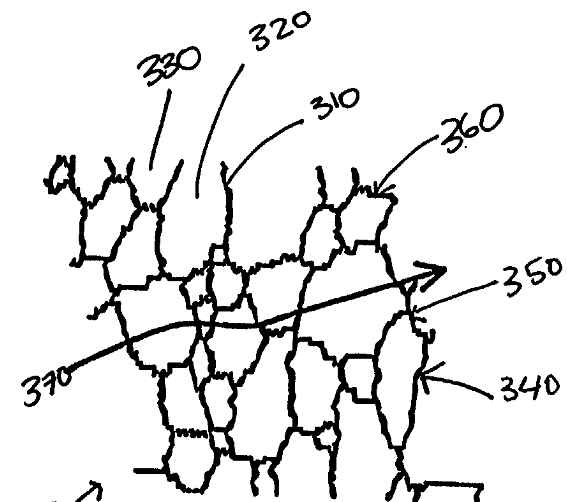

Figure 3

Attorney's Docket No.: 042390.P9481 PATENT

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION
(FOR **INTEL CORPORATION** PATENT APPLICATIONS)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled
METALLURGICALLY ENHANCED HEAT SINK

the specification of which

X is attached hereto.
___ was filed on (MM/DD/YYYY) ____________________ as
United States Application Number ____________
or PCT International Application Number ____________
and was amended on (MM/DD/YYYY) ____________.
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to this application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s) | | | Priority Claimed

(Number)	(Country)	(Foreign Filing Date - MM/DD/YYYY)	Yes No
(Number)	(Country)	(Foreign Filing Date - MM/DD/YYYY)	Yes No
(Number)	(Country)	(Foreign Filing Date - MM/DD/YYYY)	Yes No

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below:

Application Number	(Filing Date – MM/DD/YYYY)
Application Number	(Filing Date – MM/DD/YYYY)

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Application Number	(Filing Date – MM/DD/YYYY)	Status -- patented, pending, abandoned
Application Number	(Filing Date – MM/DD/YYYY)	Status -- patented, pending, abandoned

I hereby appoint the persons listed on Appendix A hereto (which is incorporated by reference and a part of this document) as my respective patent attorneys and patent agents, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

Send correspondence to Michael A. Bernadicou, BLAKELY, SOKOLOFF, TAYLOR &
(Name of Attorney or Agent)
ZAFMAN LLP, 12400 Wilshire Boulevard 7th Floor, Los Angeles, California 90025 and direct telephone calls to Michael A. Bernadicou, (408) 720-8300.
(Name of Attorney or Agent)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's Signature ______________________ Date ______________

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Full Name of Fifth/Joint Inventor ______________________

Inventor's Signature ______________________ Date ______________

Residence ______________________ (City, State) Citizenship ______________ (Country)

Post Office Address ______________________

Full Name of Sixth/Joint Inventor ______________________

Inventor's Signature ______________________ Date ______________

Residence ______________________ (City, State) Citizenship ______________ (Country)

Post Office Address ______________________

Full Name of Seventh/Joint Inventor ______________________

Inventor's Signature ______________________ Date ______________

Residence ______________________ (City, State) Citizenship ______________ (Country)

Post Office Address ______________________

APPENDIX A

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APPENDIX B

Title 37, Code of Federal Regulations, Section 1.56
Duty to Disclose Information Material to Patentability

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclosure information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclosure all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) Prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) The closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made or record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application;

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.